Assessment of fruit-bats and bats in the Kafa Biosphere Reserve

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1 HIGHLIGHTS

- This is first time a systematic bat assessment has been conducted in the Kafa BR.
- We recorded four fruit-bat species, one of which is new for the Kafa region but not for Ethiopia.
- We recorded 29 bat species by capture or sound records in our study, five bat species are new for the Kafa region but occur in other parts of Ethiopia.
- We recorded calls of a new species of the Horseshoe bat Family for Ethiopia by echolocation, this data has to be confirmed by capture because there is a chance it could be a species of *Rhinolophus* new to science.
- We suggest two flagship species, the Long-haired Rousette for the bamboo forest and the Hammer-headed fruit Bat for AW Gummi-River.
- The bamboo forests had the most bat activity in the night, but the Gojeb Wetland had the highest total of species richness because of highly diverse habitats.
- All caves in the entire Kafa-area should be protected as bat roosts.
- It will be necessary to develop an old tree management concept for the biosphere reserve to protect and increase tree roosts for bats.

2 INTRODUCTION

Ethiopia is home to a high mega- and microbat diversity, due to its special geographical position between the sub-Saharan region, East Africa and the Arabic Peninsula. In Africa, all megabats belong to the Old World Fruit Bat Family (Pteropodidae). To date, 11 fruit bat species were recorded for Ethiopia (Mammals of Africa Vol. IV 2013). All species are vegetarians and forage mainly on nectar, flowers, fruits or leaves. Like all megabats, they mainly roost in trees or caves. Their echolocation system is rudimentary; they produce broadband clicks only for orientation in caves, outside the caves their orientation is based on vision and smell of their food. In contrast, microbats (bats) produce high frequency calls for orientation and foraging. They are mainly insectivorous, only the members of the African False Vampire Family forage (Csaga, 1996) sporadically on scorpions and centipedes. These

bats roost in caves, hollow trees, under leaves or bridges or in buildings (at the study sites, no buildings suitable for bats were available, except for the Guesthouse in Bonga). So far, 70 bat species were recorded for Ethiopia, 5 of them endemic to Ethiopia.

Looking on a higher taxonomic level, the following families were recorded for Ethiopia to date: one family of megabats (Pteropodidae with 11 species) and nine bat families (Rhinopomatidae with 2 species, Rhinolophidae with 8 species, Hipposideridae with 7 species, Emballonuridae with 3 species, Nycteridae with 5 species, Megadermatidae with 2 species, Molossidae with 12 species, Miniopteridae with 3 species and Vespertilionidae with 28 species) (African Chiroptera Report 2014, see also Table Appendix 1).

For the Kafa Region, only poor data exist, gathered during a Russian Excursion (Lavrenchenko 2004) and recorded from few Museum specimens.

Table 1: Bats and fruit bats species richness in Ethiopia (African Chiroptera Report 2014; Mammals of Africa Vol IV 2013 and own data).

	Species in Ethiopia	Species in the Kafa Region	new records for the Kafa Region (this study)
bats	70	29	5 confirmed
fruit-bats	11	7	1 confirmed

Little is known about the habitat use and food preference of most of the African bat species. Only very few publications comment on the distribution of bat species (type of habitat used and altitudinal distribution) or food preferences within Africa.

The presented survey is a first attempt to get a rough overview on the bat fauna in the Kafa BR. Despite the comparatively short time of the assessment, the data quality is to be considered high, as the records are not only based on captured animals or museum specimens. With our sound recording equipment we were able to register even high flying bats which are generally underrepresented in surveys based on traditional recording methods such as mist-netting (which biases surveys due to the small vertical trapping height of about 4 m). The high flying bats that were recorded mainly belonged to the Molosside family. They utter very loud echolocation calls, which can be recorded well over long distances or when they are flying high over habitats.

3 MATERIALS AND METHODS

3.1 Study sites

We sampled at the following sites: BA-Bamboo Forest, BK-Boka Forest, AW, GO-wet- Gojeb Wetland, KDA-Bonga Guesthouse, God`s Bridge (near Bonga). Table 2 gives an overview on sampling dates and conditions at the sites.

Table 2: Sampling sites

Date 2014	Location	No. Mist nets	sound record	Alti-tude (m)	GPS Data	Time	Temp. 9pm (°C)	Hum itity	moon
BA -Bamboo Forest									

12-04	clearing	2	1	2595	7.240562°	36.452092°	6-12pm	11,6	53%	95%
	along the road	1	no	2592	7.241319°	36.452568°	6pm-6am			
	In the forest	no	1	2668	7.244722°	36.457697°	6pm-6am			
BK -Boka Forest										
12-05	border of forest	1	1	2407	7.298308°	36.373251°	6-10pm	15,6	53%	100%
	in the forest	1	no	2445	7.298523°	36.372913°	6-10pm			
	on the small river	0	1	2435	7.296747°	36.372911°	6-10pm			
AW										
12-07	at Gummi River	3	1	1289	7.095167°	36.232394°	6pm-6am	15		95%
	coffee plantation	0	1	1299	7.094387°	36.227896°	6-12pm			
GO-wet -Gojeb Wetland										
12-09	Garden/house	1	1	1550	7.566865°	36.049964°	7pm-6am	15		85%
	hedge	1	no	1558	7.563601°	36.047500°	6-10pm			
	on the river	0	1	1535	7.552917°	36.056020°	6pm-6am			
12-10	carwash	1	1	1532	7.555848°	36.056959°	6-11pm	15	82%	80%
	at the road - core area	1	no	2100	7.549455°	36.053231°	6-10pm			
	forest fragment	0	1	1495	7.559498°	36.049623°	6pm-6am			
12-11	at the bridge	2	1	1537	7.554960°	36.059750°	6-11pm	13,6	75%	75%
	Coffee plantation	0	1	1535	7.557583°	36.054940°	6pm-6am			
KDA -Guesthouse Bonga										
12-03	on compound	3	0	1756	7.250151°	36.254611°	6-11:30pm	12,9	65%	75%
12-08	tree at the house	no	1	1760	7.251088°	36.254992°	6pm-6am	no data		82%
12-11	tree at the house	no	1	1760	7.251088°	36.254992°	6pm-6am	no data		75%
God's Bridge										
12-06		0	1	807	7.182593°	36.268254°	6-7:30pm	20	no data	98%
12-08		1	1	807	7.182593°	36.268254°	6-7pm	no data		82%

3.2 Sampling methods

3.2.1 Mist nets

We used nylon mist nets with a total height of 2,5m and a width of 3, 6 and 12 meters. We did mist netting in all study areas. The nets were only mounted for the entire night on the riverside of the Bamboo forest and at Gumi River. At all other sites either the light of the full moon or the humidity disturbed the bat activity, so we removed the nets before midnight.

We measured all captured bats (length of forearm, fingers, ear or tail and weight (see Table 3)

In addition to the body measurements we took a tissue sample from each individual by taking a biopsy punch out of the upper wing membrane (stamps with a diameter of 2mm for bats and 5mm for fruit-bats). These samples were stored in 80% alcohol for DNA analysis at the Natural Museum of Berlin by the group of Dr. Frieder Mayer - experts in identifying bat and fruit-bat species based on DNA sequences.

Fig. 1: Mounting the mist net

3.2.2 Sound recordings

To record bat echolocation signals, we used two batcorders (®ecoObs/Germany) with a frequency range from 14 kHz up to 200 kHz (sampling frequency 500 kHz, amplitude - 36dB) and one bat logger ® (Elekon/Switzerland) with a frequency range of 12-155 kHz (sampling frequency 312,5 kHz). Stationary recordings with the batcorder system were done at nearly all study sites throughout the whole night. Sound recordings from captured bats were made with the bat logger. We used the same system for the recordings on the Gojeb River and God's Bridge. The call sequences were stored on SDHC cards.

Fig. 2: Stationary sound recording-batcorder

3.3 Data analysis

To identify the bats species we used identification keys (measurement data) from publications for captured bats. Species we couldn't identify to species level we took to Germany for further investigations. Samples were properly prepared and exported to Germany in accordance with the national regulations of the Ethiopian Biodiversity Institute (EBI), with the main objective to further identify the species and complete the species list

The DNA analysis of the tissue samples is still in process. The identification process is done in collaboration with Dr. Frieder Mayer of the Museum of Natural History in Berlin, who is responsible for the DNA analysis. We also collaborate with Dr. R. Hutter (Museum Alexander König, Bonn), who is conducting X-rays of the unknown Pipistrelle/Neoromica species to identify the form/shape of the bacula (penis bone). This new method will help us to identify this species.

3.3.1 Identification by sound records

We identified the Hammer-headed Bat by its mating calls at Gumi River. The species identification by sound recording was based on personal acoustic experience and data identification results from scientific literature. We analysed the records with the application Selena ® Uni. Tuebingen.

The identification of African bat species by echolocation calls is a difficult task because certain call parameters to distinguish species do not exist. The data on species' specific call frequencies differ between publications. This could be a result of the use of different recording systems in the past and the varying quality of the recordings (Monadjem A 2001; Mammals of Africa Vol IV-Bats; African Chiroptera Report 2014, Collen 2012).

In this study, we identified the species by means of echolocation calls using the start- and end frequency of the sounds, the sound duration and the sound intervals. With exception of the *Myotis, Cardioderma* and *Taphozous* species, we used the data of constant-frequent component (cf) derived from the sounds for classification. We didn't classify the species using best-frequency, as his parameter is highly variable within one species and depends on their echolocation tasks. The echolocation calls, and therefore also the best frequency of each call, vary depending on whether the bat is in search or commuting flight mode, or when the bats get closer to objects or prey.

4 RESULTS AND DISCUSSION

4.1 BA- Bamboo Forest

The hunting activity was high at the beginning of the night, both on the riverside and deep into the Bamboo forest at this site (Fig.5). Nevertheless, this activity only continued until morning in the forest. The results of the insect team have shown that there was an abundance of mosquitoes, flies and beetles at this humid study site, which may explain the large number of bats.

Fig. 3: Bamboo forest study sites-map Google earth

Our echolocation data suggests that the recorded Myotis species (Table 4) could be *Myotis welwitschii*, which appears at an altitudinal range of about 2.000 meters. But both *Myotis tricolor* and *Myotis scotii* (an endemic *Myotis* species for Ethiopia) can also be found in higher montane altitudes. Knowledge of the echolocation calls of all the three species is rare (Taylor 1999) and the data from literature vary considerably. We also found different *Molossides* hunting above the forest, as well as bats from the subgenera *Scotophilus, Scotecus* and *Miniopterus.*

Fig. 4: Stationary sound recording in the Bamboo forest

Additionally to sound recordings, we set up three mist nets. Two of the nets were located on the riverside and one along the road next to our camping site. On the riverside we didn't record any bat activity after 9:30pm, whereas in the bamboo forest and above the forest we recorded continuing hunting call sequences from sunset to sunrise. This finding could be a consequence of the increasing brightness of the moon and/or the very low temperature (5^0C) outside the forest at that time, since

other studies have found that insect activity is influenced by temperature and that the temperatures inside the forest might be higher than outside during the night.

In total, we captured two fruit bats, the Long-haired Rousette and five other bat individuals. Two of them belonged to Geoffroys horseshoe bats (*Rhinolophus clivosus*/subspecies *acrotis*?), the other 3 to the subspecies Pipistrellus/Neoromica. (Table 3). The analysis of the tissue samples is still in progress h.

4.2 BK - Boka Forest

We set up our first mist net on the border of a primary forest. The second was placed inside the forest, 10 meters from the forest's edge.

The bat activity on both nets was very low; we registered only few sound recordings. The temperature fell below 5°C, so that the nets became wet and were detectable for hunting or commuting bats. Additionally, the full moon illuminated the mist net outside of the forest.

Fig. 5: Boka forest sample sites- map Google earth

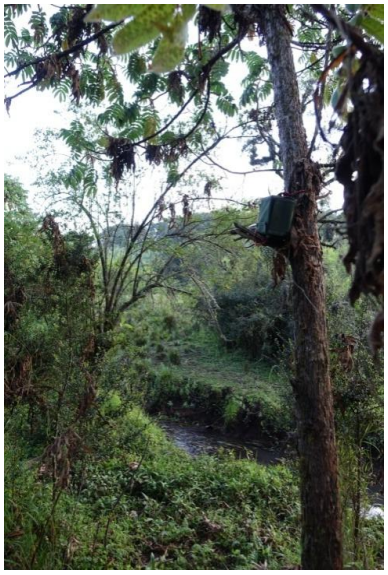

Fig. 6: Stationary sound recording at the creek/BK

Probably due to these conditions, we did not capture any bats and recorded only 10 bat sounds before removing the nets. While waiting for the bats, we recognized a high activity of nightjars in the valley, which were apparently in the mating season. One big owl flew over the net. In addition to the netting, we also installed a batcorder system on a tree on the banks of the small river, which flows through the valley (Fig. 5). The riverside vegetation is composed of shrubs and trees, none of which are higher than 5 meters. Riverbanks and wetlands are used for cattle grazing. The acoustic system recorded a high activity of *Myotis* species, which were hunting over and along the small creek. The peak frequency of the calls suggested the Welwitsch's Bat (*Myotis welwitschii).* Additionally we recorded calls of the *Miniopterus, Chaerephon* and *Pipistrelle species.*

4.3 AW - Gummi River

The habitat along the Gumi River looks more or less like a primary forest with some large *Ficus* trees, but about 100-150 Meters beyond the forest's edge we found coffee-plantations (Participatory Forest Management sites). Even on the way to the riverside we found traps, so the area might not be entirely free of human disturbance. We spent the whole night at the riverside, as the night temperature did not fall below 12^0C.We

Fig. 7: AW sample sites-map Google earth

installed three nets along the river (Fig. 8). Within a minute we captured a bat from the Nycteridae family. The species is not confirmed yet.

Fig. 8: Mist net at Gummi Riverside

Though we observed some fruit-bats crossing at dawn and in the morning, we did not record a high amount of bat activity at this study site. But we got the first record of the Hammer-Headed Bat in the Kafa Region, a male which sang for over 1 hour. We tried to find him but we only got a short glimpse of him before he disappeared and returned at 3am to continue with his love songs. Additionally to the netting, we did some sound recordings in the coffee plantation, where the bat activity was higher than by the riverside. We recorded the African Giant Free-tailed Bat and some calls from *Molosside, Myotis* and *Pipistrelle* species.

4.4 GO-wet -Gojeb Wetland

This study site is very diverse in habitats, so we spent 3 nights there. In the first night we did some netting in areas used for agriculture. In a net on a hilly hedge row we captured two *Triaenops afer*, a male and a female. In the second night we put up the nets by the side of the Gojeb River, in a small gap used by the locals to wash their cars, and the second net along the road in the hilly primary core zone forest. We dismantled the nets at 11pm as we had not captured any specimens so far and did not expect to, due to the low bat activity. Later, however, we experienced high activity when we were walking over the Gojeb River Bridge.

Fig. 9: Gojeb Wetland sample sites- map Google earth.

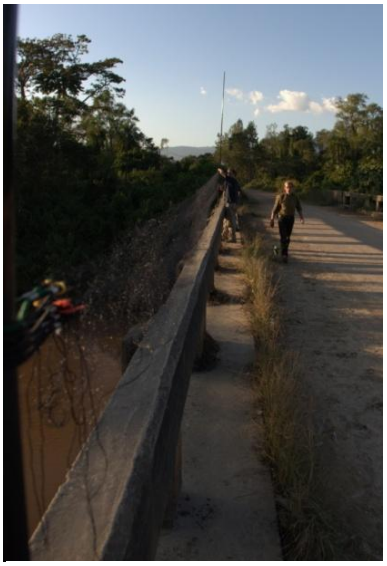

Fig. 10: Mist net on Gojeb River Bridge.

In the third night we set up one net at the bridge. We placed another self-made net (3x3m) on the river surface to catch the bats we had seen hunting the night before. The behaviour of these bats looks like the Daubenton's bat behaviour in Europe. They hunt for insects over the water's surface. Unfortunately, the pole holding up the net disturbed the water surface, so the bat recognized it as an obstacle and didn't go into the net.

The long mist net (Fig. 10) along the bridge was more successful: We captured two fruit- bats and a high flying Molosside bat. The female Molosside belonged to Chapin's Free-tailed Bat (*Chaerephon chapini*) and the fruit-bats to a subspecies of the Egyptian Fruit-bat (*Rousettus aegypticus leachii).* For the Chapin's Free-tailed Bat this will be the first confirmed record for the Kafa Region.

Fig. 11: Stationary sound recording at a forest fragment.

Stationary sound recordings were also carried out in a fragmented forest (Fig. 11) area in the wetland, on a coffee plantation near the road and at the side of the Gojeb River.

Rivers are very attractive for bats for water intake, especially in the dry season when water availability is reduced. This explains why we got a high variability of 20 bat species at this study side (Table 4). Some of our records matched to species which are rarely recorded in Ethiopia, such as the Large-eared Free-tailed Bat (*Otomops martiensseni*).

For *O. martiensseni* our data presents the first record for the Kafa Region. Within the coffee plantation we got calls from a hunting African Trident bat (*Triaenops afer*). Additionally, we found a high variety of *Myotis, Molosside* and *Pipistrelle* species by the riverside.

4.5 KDA Guesthouse

At the compound of the KDA Guesthouse in Bonga we set up mist nets for one night. Two nets were set up in front of a mango tree in blossom and other nets on the north border of the compound. We only captured two fruit-bats of Peter's Lesser Epaulled (*Micropteropus pusillus)* in front of the Mango trees at midnight, a male and a female. Additionally, we did some stationary sound recording on two nights, on the 8th and 11th of December. We recorded calls from several *Molosside, Miniopterus* and *Pipistelle* species.

Fig. 12: KDA -Bonga sample site.

4.6 God's Bridge

Near Bonga town there is a natural stone bridge over the river called God's Bridge – one of the area's touristic attractions (Fig.14).This cave-like structure is used as a roosting site by some fruit-bat and bat species. We recorded echolocation calls from *Miniopterus, Pipistrelle* and *Myotis* species. In addition, we observedfruit-bats circle under the bridge, but we're unable to catch them. Even the bats leaving the cave recognized our mist net at the entrance and avoided it. We only had visual contact to some perch-hunting Rhinolophids. All echolocation calls from Hipposiderids or Rhinolophids were distinguished by the cf-part of their calls. We got records of Noack's Leaf-nosed Bat (*Hipposideros ruber)* and perhaps of Smither's Horseshoe bat (*Rhinolophus smithersi*).Taylor (2012) found four new species belonging to the *Rhinolophus hildebrandtii*-Complex in his South-East African study in 2012. *Rh. smithersi* is one of them. This species has never been recorded outside of Zimbabwe and has to be confirmed by capture in the future. As of now it is not clear if *Rhinolophus hildebrandii* and/or *Rhinolophs eleoquens* really occur in Ethiopia.

Fig. 13: God's Bridge near Bonga

Our echolocation results implicate that some of the records of *Rhinolophus* species in Ethiopia before mentioned actually belong to the new *Rhinolophus smithersi* (cf freq. 46 kHz) or to a new Rhinolophide species.

5 CONCLUSIONS AND RECOMMENDATIONS FOR CONSERVATION AND MONITORING

Since we mostly sampled the sites for only one night, we could not generated accumulation curves for the fruit-bat or bat species. As flagship species, we propose the Long -haired Rousette (*Rousettus/Stenonycteris lanosus*) for the Bamboo forest and the Hammer-headed (fruit) Bat (*Hypsignatus monstrosus)* for AW-Gumi Riverside. For all other species we can only make rough suggestions for conservation and further surveys in this region.

We detected a high amount of the sound recordings and captured half of all bats with mist nets in the Bamboo forest at a high altitude (2.700 m). At a first glance, this seems to be astonishing, but might be explained by our theory that the supply of roosting places and food in this region were the highest of all areas we surveyed. Even the insect team found a high amount of insects in the Bamboo forest.

The highest species richness was found in the Gojeb Wetland. Highly diverse habitats and a large variety of food (due to the warmer climate) may explain this result.

We confirmed four species of fruit-bat and more than 29 different bat species (less than half of the known bat species in Ethiopia) in our short study period. Most of the echolocation records will need to be confirmed by capture, but nevertheless we recorded 6 new species for the Kafa BR and one new to Ethiopia. The Rhinolophus species we recorded at God's Bridge could be *Rhinolphus smithersi,* judging by the echolocation recordings, which has only been found in Zimbabwe until now, or we recorded a new species of the Family Rhinolopidea. It will necessary to capture some individuals at God's Bridge to confirm this data.

5.1 Conservation and key species

The human activities that pose the greatest threats for bats in Africa are among others the habitat loss and the use of pesticides. There is very little information about the habitat use, food or roost preferences of most of the bat species. A key step to successfully protect the bat fauna is to the supply of a high amount of old, hollow trees or caves for roosting include in conservation plans. Caves play an important role as roosting sites for almost all bat species. Existing cave roosts should be protected. Especially at God`s Bride, which is a tourist attraction, the bats should be protected from people who could disturb the colonies during their visit. The installation of an information board at the entrance could help to protect the animals (bats and birds) which live in the cave.

To increase the amount of tree roosting sites it will be necessary to develop an old tree management concept for the biosphere. At the moment, old dead trees are removed to serve as firewood. Similarly, to improve the roosting conditions it is necessary to have a high abundance of insects in the area, which could be supported by for example creating patches of managed and natural forests' continuum corridors.

Fruit bats often roosts in caves, under palm branches or hanging on the branches of trees. For the family Pteropodidae (fruit- bats) it is essential to have enough blossom or fruiting trees in the area, so that the bats can find enough food. It is also known that some fruit-bat species migrate seasonally between habitats with profitable food sources, often even over long distances. Plans of increasing commercial tree plantations (i.e. fruits) can become a problem for bat conservation in the future; as they will eat the fruit if there are not enough natural food resources left.

For protection of the very rare (Long-haired Rousette) or delicate (Long-haired Rousette; Hammer-headed Bat) flagship species, it would be useful to have more data on their behaviour, habitats use and roosting sites, which should be acquired by further research in the area.

5.2 Future plan of bat monitoring

Future studies should monitor bats at all seasons (dry-wet-transition phase) and also to pay more attention to the moon cycle, e.g. the influence of the full moon on bat activity .To get an overview of the species composition of the bat fauna of certain areas it would be helpful to first monitor caves and roosting sites before continuing the research with mist netting or bioacoustics. In order to have comprehensive and robust results it is important to consider a minimum of 7 days of sampling/observation, including all seasons, at each study sites. To confirm the new Rhinolophus species it will be necessary to capture some specimens at God's Bridge for body measurements and tissue samples.

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7 APPENDIX

Table 3: Bat-list Ethiopia (IUCN category: NT near threated, DD data deficient, LC least concern, V vulnerable).

	English name	Altitude Meter	in Ethiopia reported	in Kafa reported	IUCN category
Fruit-Bats: Family Pteropodidae					
***Rousettus** aegypticus leachii*	Egyptian Fruit Bat	2.500	**x**	**x**	LC
- lanosus	Long Haired Rousette/ Mountain Fruit Bat	2.500	**x**	**x**	LC
***Lissonycteris** angolensis*	Angolian soft-furred fruit bat	4.000	**x**		LC
- angol. petraea ***	Petra Fruit Bat	2.600	**x**	**x**	DD
***Eidolon** helvum*	Straw-coloured Fruit Bat	1.900	**x**		NF
***Hypsignatus** monstrosus*	Hammer-Headed Bat	1.200	**x**	new record	LC
***Epomophorus** gambianus*	Gambian Epauletted Fruit Bat	2.150	**x**	**x**	LC
- labiatus	Ethiopian Epauletted Fruit Bat	2.500	**x**	**(x)**	LC
- minimus	East African Epauletted Fruit Bat	savanna	**x**	**x**	LC
- minor	Minor Epauletted Fruit Bat	no data	**x**		Unknown
***Micropteropus** pusillus*	Peter's Dwarf Epauletted Fruit Bat	1.900	**x**	**x**	LC
Bats: Family Emballonuridae					
***Taphozous** perforatus*	Egyptian Tomb Bat	1.600	**x**	**x**	LC
- mauritianus	Mauritian Tomb Bat	500	**x**	new record	LC
***Coleura** afra*	African Sheath-Tailed Bat	1.700	**x**	**x**	LC
Family Hipposideridae					
***Hipposideros** caffer*	Sundevall'sRoundleaf Bat	2.000	**x**	**(x)**	LC
- vittatus (marungensis)	Striped Leaf-nosed Bat	lowland	**x**		NT
- megalotis	Ethiopian Large-eared Roundleaf Bat	2.000	**x**		LC
- ruber	Noack'sRoundleaf Bat	1.900	**x**	**x**	LC
***Triaenops** afer*	Persian Trident Bat	1.700	**x**	**x**	LC
***Asellia** patrizii*	Patrizi's Trident Leaf-nosed Bat	1.000	**x**		LC
- tridens	Trident Bat	1.000	**x**		LC
Family Megadermatidae					
***Lavia** frons rex*	Yellow-winged Bat	1.400	**x**		LC
***Cardioderma** cor*	Heart-nosed Bat	1.400	**x**	new record	LC
Family Miniopteridae					
***Miniopterus** natalensis*	Natal Long-fingered Bat	2.700	**x**	**x**	LC
- schreibersi smitianus	Schreibers Long-fingered Bat	no data	**x**	**(x)**	NT
- inflatus	Greater Long-Fingered Bat	3.300	**x**		LC

	English name	Altitude Meter	in Ethiopia reported	in Kafa reported	IUCN category
Family Nycteridae					
***Nycteris** aurita*	Andersen's Slit-faced Bat	1.500	**x**		LC
- hispida	Hairy Slit-faces Bat	1.800	**x**	**x**	LC
- macrotis	Large-eared Slit-faced Bat	2.200	**x**	**(x)**	LC
- parissi	Parisi's Slit-facedBat	no data	**x**		DD
- thebaica	Egyptian Slit-faced Bat	2.400	**x**	**x**	LC
Family Molossidae					
***Otomop**s martiensseni*	Large-eared Free-tailed Bat	1.300	**x**	new record	NT
***Platymops** setiger*	Peters's Flat-headed Bat	900	**x**		LC
***Mops** condylurus*	Angolan Free-tailed Bat	1.700	**x**	**(x)**	LC
***Mormoptereus** acetabulosus*	Mauritian Little Mastiff Bat	2.000	**x**		V
***Tadarida** nanula*	Dwarf Free-tailed Bat	500	**x**		LC
-ventralis	African Giant Free-tailed Bat	1.800	**x**	new record	DD
***Chaerephon** ansorgei*	Ansorge's free-tailed Bat	2.500	**x**	**(x)**	LC
-bivittatus	Spotted Free-tailed Bat	2.500	**x**		LC
-chapini	Chapin's Free-tailed Bat	1.800	**x**	new record	LC
-leucogaster	Grandidier's Free-tailed Bat	no data	**x**	**(x)**	DD
-pumila	Little Free-tailed Bat	2.200	**x**	**x**	LC
-nigeriae	Nigerian Free-tailed Bat	1.100	**x**		LC
Family Rhinolphidae					
Rhinolophus clivosus acrotis	Geoffroy's Horseshoe Bat	3.000	x	(x)	LC
- blasii andreinii	Blasius's Horseshoe Bat	2.000	**x**		LC
- eloquens	Eloquent Horseshoe Bat	no data	**x**		LC
- hildebrandtii	Hildebrandt's Horseshoe Bat	2.400	**x**		LC
- fumigatus	Rüppell's Horseshoe Bat	2.400	**x**		LC
- hipposideros-minimus	Lesser Horseshoe Bat	1.400	**x**		LC
-landeri lobatus	Lander's Horseshoe Bat	2.200	**x**	**x**	LC
-simulator	Bushveld Horseshoe Bat	3.000	**x**		LC
-smthersi	Smithers's Horseshoe Bat	no data	new record	new record	DD
Family Rhinopomatidae					
***Rhinopoma** hardwickei-cystops*	Lesser Mouse-tailed Bat	1.000	**x**	**(x)**	LC
-macinnesi	Macinnes's Mouse-tailed Bat	1.000	**x**		DD
Family Vespertilionidae					
***Kervoula** lanosa*	Lesser Woolly Bat	1.000	**x**		LC
*-eriphora***	Ethiopian Woolly Bat	3.300	**x**		DD
***Myotis** bocagii*	Rufous Mouse-eared Bat	2.400	**x**	**x**	LC

	English name	Altitude Meter	in Ethiopia reported	in Kafa reported	IUCN category
-morrisi	Morris' Mouse-eared Bat	900	**x**		DD
*-scotti****	Scott's Mouse-eared Bat	2.500	**x**	**x**	V
-tricolor	Cape Hairy Bat	2.600	**x**		LC
-welwitschii	Welwitsch's Bat	2.200	**x**	**x**	LC
Plecotus** balensis*	Ethiopian Big-eared Bat	3.300	**x**		V
***Mimetillus** moloneyi*	Moloney's Mimic Bat	500	**x**	**(x)**	LC
***Laephotis** wintoni*	De Winton's Long-eared Bat	1.700	**x**	**x**	LC
***Nycticeinops** schlieffeni*	Schlieffen's Bat	900	**x**		LC
***Scotophilus** dinganii*	Yellow-bellied House Bat	2.150	**x**	**x**	LC
-ejetai*	Ejetas House Bat	no data	**x**		DD
-leucogaster	White-bellied House Bat	2.200	**x**		LC
-viridis nigritellus	Greenish Housed Bat	montane	**x**		LC
***Scotoecus** hirundo*	Dark-winged Lesser House Bat	1.500	**x**	**(x)**	LC
***Scotoecus** hindei*	Hinde's Lesser House Bat	1.800	**x**		DD
***Glauconyncertis** variegata*	Variegated Butterfly Bat	1.000	**x**		LC
***Pipstrellus** aero*	Mount Gargues Pipistrelle	2.500	**x**		DD
-hesperidus	Dusk/African Pipistrelle	3.000	**x**	**x**	LC
-nanus africanus/N.nana	Banana Pipistrelle	2.500	**x**	**x**	LC
-rusticus	Rusty Pipistrelle	2.100	**x**	**x**	LC
-rueppelli	Rüppell' s pipistrelle	2.500	**x**		LC
***Neoromicia** guineensis*	Tiny Serotine/	1.900	**x**		LC
-capensis	Cape Serotine	600	**x**	**x**	LC
-somalicus	Somali Serotine	1.900	**x**	**x**	LC
-tenuipinnis	White-winged Serotine	2.300	**x**		LC
-zuluensis	Zulu Pipistrelle	2.600	**x**		LC

Table 4: Results from capture data and sound analysis.

Family	Species name		BA	BK	AW		Go-wet			God's	KDA
			Bamboo Forest	Boka Forest	Gummi River	Coffeeplan.	Forest fragment	River	Meadow Coffee-plan	**Bridge**	Bonga
Pteropodidea /fruit-bats											
	Hammer-Headed Fruit-bat	*Hypsignatus monstrosus*			**x**[2]						
	Peters's Lesser Epaulled Fruit-bat	*Micropteropus pusillus*									**x**[1]
	Long-Haired Rousette	*Stenonycteris lanosus*	**x**[1]								
	Egyptian Rousette	*Rousettus rous. leachii*						**x**[1]			
		Fruit bats spec								**x**	
Emballonuridae											
	Mauritan Tomb Bat	*Taphozous mauritianus*						**x** [2]			
Hipposideridae											
	Noack's Leaf-nosed Bat	*Hipposideros ruber*								**x** [2]	
	African Trident Bat	*Triaenops afer*					**x** [2]	**x** [2]	**x** [1]		
Megadermatidea											
	Heart-nosed Bat	*Cardioderma cor*						**x** [2]			
Miniopteridae											
		Min 45 [*Miniopterus inflatus*]	**x**								
		Min 52 [*Miniopterus natalensis*]	**x**	**x**			**x**				
		Min 56 [*Miniopterus spec*]	**x**					**x**	**x**	**x**	**x**
Molossidea											
	Long-eared Giant Mastiff Bat	*Otomops martiensseni*						**x** [2]			
	Pale Free-tailed Bat	*Chaerephon chapini*	**x**[3]					**x** [1]			

Family	Species name		BA	BK	AW		Go-wet			God's	KDA
			Bamboo Forest	Boka Forest	Gummi River	Coffeeplan.	Forest fragment	River	Meadow Coffee-plan	Bridge	Bonga
		T 15/16 [*Ch.nigeriae*]	**x**					**x**			
		T 17/18 [*Ch. ansorgei*]	**x**								
	African Giant Free-tailed Bat	*Tadarida ventralis*	**x**[2]			**x**[2]					**x**[2]
		T 25 [*Ch. pumilus*]		**x**			**x**	**x**	**x**		**x**
		T 32/34 [*Momopterus acetabulosus*]						**x**			**x**
		Mol 18/20 [*Mops condylurus*]				**x**					
Nycteridae											
		N spec *(Nycteris hispida)*			**x**[1]						
Rhinolophidae											
	Geoffroy's Horseshoe Bat	*Rhinolophus clivosus a.*	**x**[1]					**x**[2]	**x**[2]		
	???	***RH 46*** *[Rhinolophus smithersi]*								**x**	
Rhinopomatidea											
	no Rhinopomatidea										
Vespertilionidae											
		Pip 32/34 [*Pip./Neoromica spec*]						**x**			
		Pip 35/36 [*Neoromica somalicus*]	**x**					**x**	**x**		**x**
		Pip 38/39 [*Neoromica capensis*]	**x**	**x**					**x**		
		Pip 42/44 [*Pipistrellus* aero]			**x**	**x**	**x**	**x**	**x**		**x**
		Pip 50/52 [*Pipistrellus hesperidus*]					**x**	**x**		**x**	**x**

Family	Species name		BA	BK	AW		Go-wet			God's	KDA
			Bamboo Forest	Boka Forest	Gummi River	Coffeeplan.	Forest fragment	River	Meadow Coffee-plan	Bridge	Bonga
	Banana Pipistrelle	*Pipistrellus nanus/N. nana*					x [2]	x [2]	x [2]		x [2]
		Myo 28 [*Myotis bocagii*]				x		x	x		
		Myo 33 [*Myotis welwitschii*]	x	x		x		x			
		Myo 36 [*Myotis tricolor]*					x		x	x	
		S 30/32 [*Scotophilus dinganii or Scotecus hirundo]*	x					x	x		
		S 36 [*Scotophilus hindei*]	x								
		# of species/site	**14**	**4**		**7**			**22**	**6**	**9**
		# of nights/site	**1**	**1**		**1**			**3**	**1**	**3**
		# of mistnets/site	**3**	**2**		**3**			**6**	**1**	**3**
		# of sound recording/site	**3978**	**3**	**137**	**155**	**1280**	**1524**	**383**	**53**	**1574**
				x[1]	confirmed by capture				**[species]**	not confirmed	
				x[2]	confirmed by echolocation calls						
				x[3]	not confirmed						

x[1] confirmed by capture **, x[2]** confirmed by echolocation calls**, x[3]** not confirmed, **[species]** not confirmed

Confirmed fruit-bat species and their distribution (Maps taken from www. iNaturalist.org/ Mammals of Africa Vol IV; in light red-distribution in Africa).

Peter's Dwarf Epauletted Fruit Bat

Miniopteropus pusillus

Location:

KDA Guesthouse

Long Haired Rousette/ Mountain Fruit Bat

Rousettus lanosus

Captured:

Bamboo forest

Egyptian Fruit Bat

Rousettus aegypticus (leachii)

Captured:

GO-wet

Foto: © Jakob Fahr

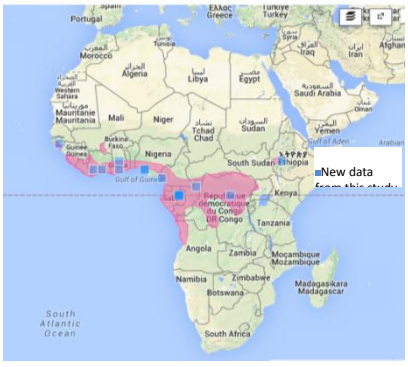
Hammer-Headed Fruit Bat

Hypsignatus monstrosus

Acoustic confirmation:

Audible Love song calls

Location: AW- Gummi Riverside



Captured bat species(Distribution, echolocation calls)

Geoffroy's Horseshoe Bat

Rhinolophus clivosus (acrotis)

Echolocation:

Sonagramm: (sound intensity color coded)

long cf-signal at 92 kHz (female), sound duration 80 ms

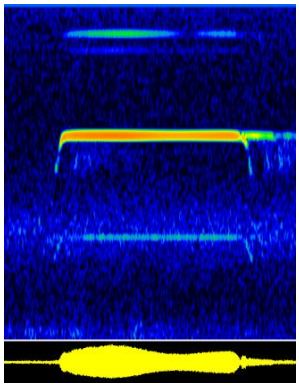
captured:

Bamboo forest

150

kHz

0



African Trident Bat

Triaenops afer

Echolocation:

short cf signal
86 kHz female/76 kHz male, sound duration 8ms

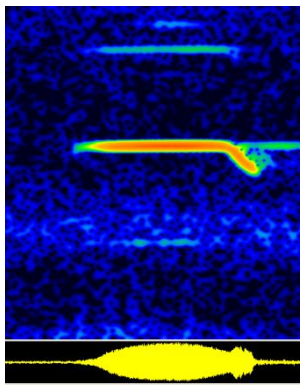
captured:

GO-wet

150

kHz

0



Chapin's Free-tailed Bat

Chaerephon chapini

Echolocation:

long quasi-cf calls
end-freq. 20 kHz, sound duration 8 ms

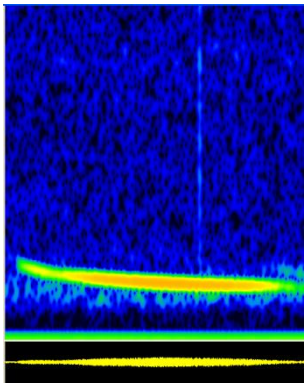
captured:

GO-wet

150

kHz

0



Nycteridae

Nycteris hispida

no sounds

Captured:

AW- Gummi River

Pipistrellus/Neoromica 1

Species not confirmed yet

captured:

Bamboo forest

Echolocation:

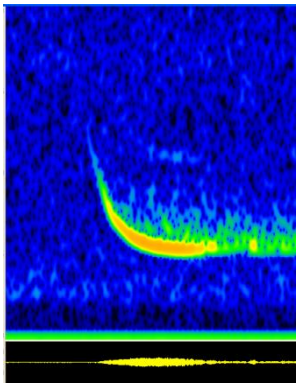
fm-cf call , cf frequency 39 kHz

sound duration 4,5ms

150

kHz

0



Pipistrellus/Neoromica 2

Specie not confirmed yet

captured:

Bamboo forest

Echolocation:

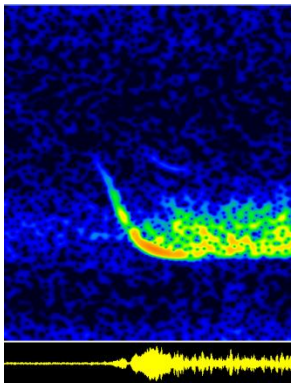
fm-cf call , cf frequency 37 kHz

sound duration 3,5 ms

150

kHz

0

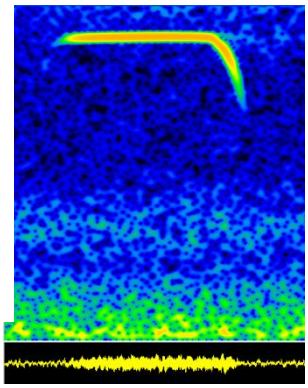


Acoustic confirmed bat species(Sonagram of echolocation calls)

150

kHz

0



Noack's Roundleaf Bat

Hipposideros ruber

Acoustic confirmation:

Short cf signal

cf-freq. at 135 kHz

sound duration 8 ms

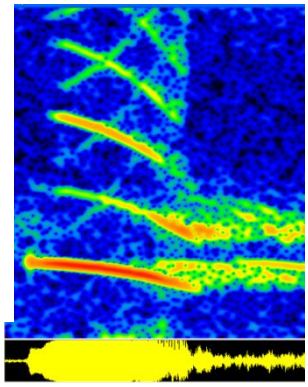
recorded at:

God's Bridge

150

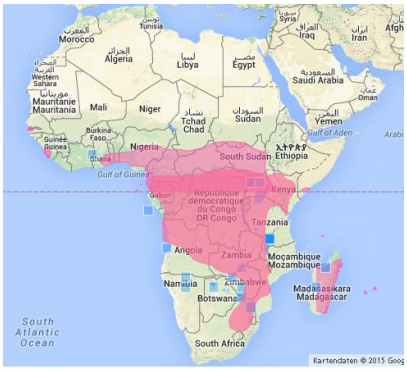
kHz

0



Mauritian Tomb Bat

Taphozous mauritianus



Acoustic confirmation:

Long multi-harmonic signal

end-freq. 1 harm. 25 kHz

sound duration 8ms

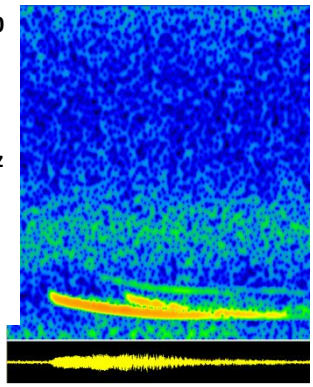
recorded at:

GO-wet

150

kHz

0



Large-eared Free-tailed Bat

Otomops martiensseni

Acoustic confirmation

Long quasi-cf signals at 9 kHz

Sound duration 10ms

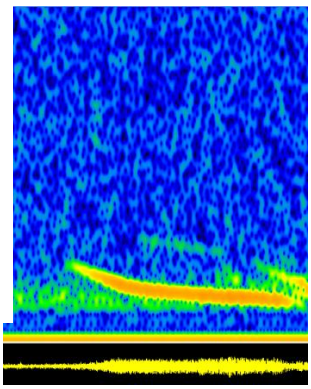
recorded at:

GO-wet

150

kHz

0



African Giant Free-tailed Bat

Tadarida ventralis

Acoustic confirmation:

Long quasi cf-fm signal 18 kHz

sound duration 11 ms

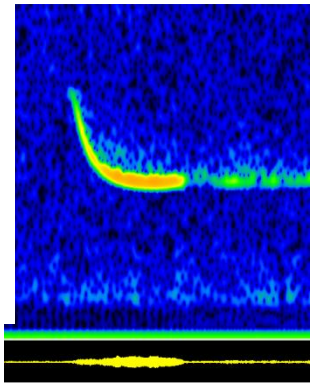
recorded at:

GO-wet

150

kHz

0



Banana Pipistrelle

Pipistrellus nanus

Acoustic confirmation

fm-cf signals

cf-frequency at 71 kHz

sound duration 5ms

recorded at:

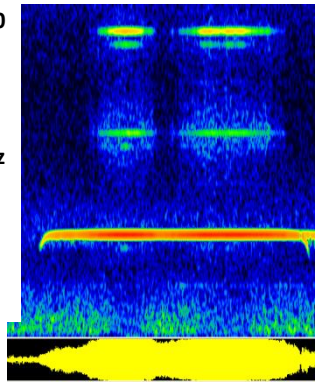
KDA

GO-wet

150

kHz

0



Smithers's Horseshoe Bat?

Rhinolphus smithersi?

or a new species

Acoustic confirmation?:

Long cf signal at 46kHz
sound duration 45 ms

?

recorded at:

God's Bridge